method with Hindu Brahmans and gentlemen, and with cultured Moslems, in India, than I find it possible to do with clerics, the professional classes, and society magnates in Britain.

It is to be hoped that "more light" will evolve at Oxford and Cambridge, and a higher and truer method permeate their sons. GUNGA-GUNGA.

A Solar Outburst (?).

REFERRING to the note on solar activity in your issue of July 20, I shall be glad to know whether any correspondent observed a luminous outburst in the tail end of the great spot on the evening of July 16. I had been observing in the afternoon with an 8½-inch reflector, but remarked nothing of the sort. At 5.30, however (the sun having got beyond range of my reflector), I was observing him with a small refractor, power 12, and sun-cap, when I at once noted the luminous appearance in question. It was roundish and about the size of the small spot near following limb, and it was brighter than the bright bridge in the large group. I watched this bright spot until 7.30; next morning it had practically disappeared. Father Cortie courteously informs me that the Stonyhurst magnets were perfectly quiet on July 16, but that next morning, at 8.15, there was a "very small but sudden and sharp movement on both the declination and horizontal force curves." By that time the locality where the luminous appearance occurred would not be far from central meridian. I also noticed a rosy hue pass over the bright bridge of great spot, but this may have been a mistake. I am, however, certain of the luminosity.

Cardiff, July 24. ARTHUR MEE.

A CENTURY'S PROGRESS IN WARSHIP DESIGN.

THE interesting paper read by the Director of Naval Construction at the summer meeting of the Institution of Naval Architects brings vividly home to us the progress made in the design of warships since Nelson fought, off Cape Trafalgar, our last great sea fight. In our account of the proceedings at the meeting, printed last week, we referred to Sir Philip Watts's paper, but it is worthy of more attention than brief mention in a report of a society's meeting.

We reproduce from among the illustrations accompanying the paper the sheer draught of Nelson's last ship, the *Victory* (Fig. 1). The original drawing of this most famous of all vessels of the Royal Navy was shown at the meeting when the paper was read. We also reproduce the sheer draught of the 36-gun frigate *Syrius* (Fig. 2), as affording an interesting comparison with a modern cruiser. As is well known, the *Victory* was forty years old at the date of Trafalgar, so that as she now floats in Portsmouth Harbour she numbers 140 years. She was, however, reconstructed in 1798, seven years before Trafalgar, and again in 1820. The effect of her first reconstruction is shown by the dotted lines of the engraving. The long time that the *Victory* remained on the active list is indicative of the slower progress of invention that characterised former times. If we go somewhat further back we have a still more striking example in the *Royal William*, a model of which 100-gun line-of-battle ship was shown at the Naval Exhibition of 1891. She was built at Chatham Yard in 1670, was rebuilt at Chatham in 1692 on the same lines as those on which she was originally designed by Phineas Pett, and was again rebuilt at Portsmouth in 1719. As she was not broken up until August, 1813, she was in existence when the battle of Trafalgar was fought; but as Sir Philip Watts does not include her in his table of ships of the Royal Navy, October, 1805, we may conclude that before that date she had ceased to be considered efficient.

The long life of the warships of past times was not due to their more durable construction as compared to modern vessels, but to the lack of that inventive enterprise now made possible, primarily, by James Watt's labours. A steel vessel well built and properly kept up would be practically indestructible with fair treatment; but the same cannot be said of wooden ships. It is not because sound wood in itself is less strong than iron or steel, weight for weight, so much as that it cannot be procured in sufficiently long and conveniently sized pieces, a large number of joints and overlappings thus being necessary; but the chief drawback to wood is that it is not so suitable a material for making joints; as Sir Philip Watts says, "The fastenings cannot develop the strength of the main body of the material." A seam of rivetting in a properly designed steel vessel will join plates to frames or beams, or plates to plates in a way that no buffeting of the winds and waves will affect. That is not the case with the fastenings of wooden ships; as a matter of fact, most of the old men-of-war became "hogged" after some years of service. The frequent reconstruction of wooden vessels of which we read was the result of these conditions.

The causes which thus led to the decay of wooden ships, as individual structures, contributed to the permanence of their respective types, especially in regard to ships of the line. As Sir Philip Watts points out, it was "owing to the limitations imposed on shipbuilding, when wood was the only available material, that length could not be largely increased without reducing to a dangerous extent the longitudinal strength of ships, and the only practicable means of largely increasing the number of guns was to increase the number of decks for carrying them." There were, however, limitations to the extension of vertical dimensions as well as to the increase of horizontal dimensions. A few four-deck ships were built, but the advantages of the extra gun positions thus secured were more than counterbalanced by the defects of a high, unwieldy structure above water. Even three-deckers were at a disadvantage owing to their high sides; they were "worse sailors and less handy in manœuvring than two-deckers"; and, indeed, when one looks at the old *Victory* towering above water, riding to her moorings in Portsmouth Harbour, one wonders how these ships were ever sailed in any direction excepting broad off the wind. The high positions of the guns also necessitated a greater amount of ballast to give stability. All these circumstances joined in confining the naval architect to short ships; and once Phineas Pett had developed construction to the full extent allowed by the limitations of wood as a material, and wind as a source of motion, there was little more to be said. Charnock, speaking of the *Prince Royal,* designed by Pett at the beginning of the seventeenth century, has said, "This vessel may be considered the parent of the identical class of shipping which, excepting the removal of such defects or trivial absurdities as long use and experience has pointed out, continues in practice even to the present moment." That sentence bridges over a period of more than 200 years of the history of naval design.

When it was recognised that iron could be used for the construction of ships—that it was not, as some averred at the time, "contrary to the laws of Nature"—then the horizon of the naval architect widened as when fog lifts at sea. To design a ship of adequate strength became a science, for the stresses that hull structure of given scantling would stand could be calculated with precision; mathematics and a knowledge of physics took the place of bolts and trenails. Before this era English models had fallen sadly behind those of our chief rivals. It was by hard fighting, not by superiority or even equality of design, that victories were gained for our arms. Creuze, in his "Treatise of Naval Architecture," published in 1846, speaks of the inferiority of British ship design, quoting Charnock to the same effect. "When an English fleet was in chase of a French fleet it was ships which were British built that fell into our possession; but almost on every occasion the French ships could evade ours. The losses sustained in the French Navy by foundering at sea, or by wrecks were principally those which had been taken from us. On the contrary, the favourite ships in our fleets were those which had been taken from the French, and the instances in which French ships in our service were ever recovered possession of by them were extremely rare; we as far exceeding them in all that related to the manœuvres and management of ships as they did us in designing them." As is well known, the *Foudroyant*, a two-deck ship captured from the French in 1758, served as a model for a new class, or, again to quote Creuze, "a very superior class of man-of-war which was adopted."

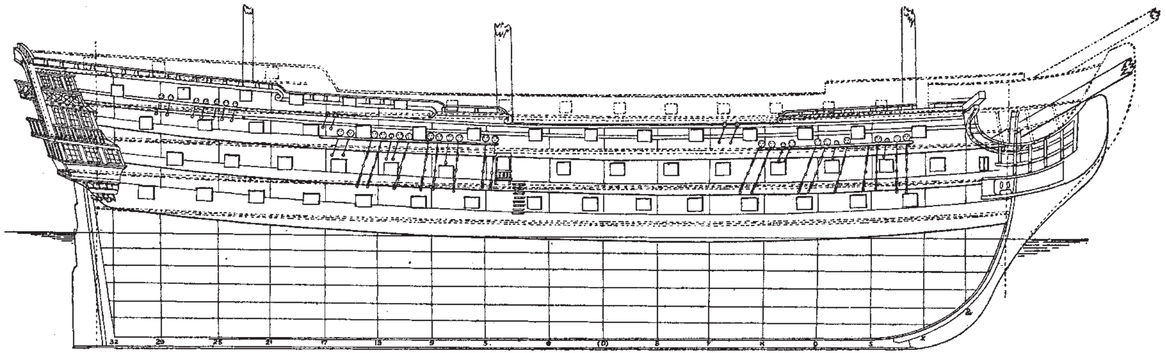

FIG. 1.—Navy Office, June 6, 1759. Sheer draught of 100-gun vessel *Victory*. Length on the gun decks, 186 ft.; Length of the keel for tonnage, 151 ft. $3\frac{5}{8}$ in.; breadth extreme, 51 ft. 10 in.; breadth moulded, 50 ft. 6 in.; depth in hold, 21 ft. 6 in.; burthen in tons, No. $2162\frac{22}{94}$; the dotted outline shows the vessel as altered.

It was not, however, with the abandonment of wood that England ceased to follow the lead of France in ship construction. We remember that the first iron-clad ocean-going war vessel, *La Gloire*, was French; and Sir William White in 1887 said, "it must be frankly admitted that the lead taken by the French on both the steam and ironclad reconstructions was the primary cause of most subsequent activity in warship building."

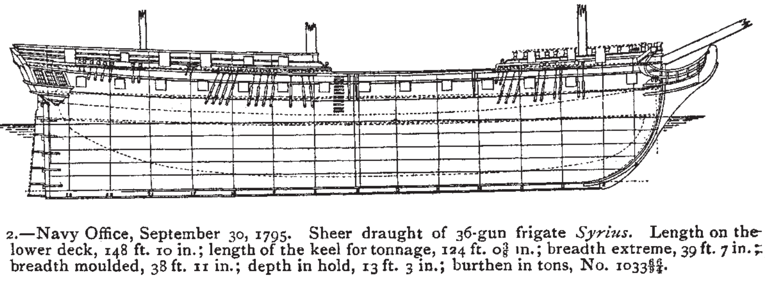

FIG. 2.—Navy Office, September 30, 1795. Sheer draught of 36-gun frigate *Syrius*. Length on the lower deck, 148 ft. 10 in.; length of the keel for tonnage, 124 ft. $0\frac{3}{8}$ in.; breadth extreme, 39 ft. 7 in.; breadth moulded, 38 ft. 11 in.; depth in hold, 13 ft. 3 in.; burthen in tons, No. $1033\frac{66}{94}$.

We dwell on this point because it illustrates the evil of neglecting the application of scientific principles to practical affairs. Happily, since the period to which we have referred Great Britain has done much to remove the reproach under which she formerly rested. The labours of Scott-Russell, Rankine, William Froude, and many others raised ship design in this country to a position of which we may well be proud. Some of the later workers, like the late William John, have passed away, but, happily, the majority—and we may cite the author of the paper as among the most distinguished—are still with us. It is fair to add that it is to the establishment of the Institution of Naval Architects this improvement is mainly due; and, since its foundation in 1860, the application of scientific principles to ship design has made progress rapid beyond all precedent. Annual meetings bring together the leading members of the profession for the interchange of ideas, and in the *Transactions* of the institution may be found memoirs by the best authorities on all subjects connected with the science of naval architecture.

It is well to remember, however, that, whilst there is much room for congratulation, the need for effort towards progress still exists, and perhaps to a greater degree than ever. For long after the introduction of steam propulsion, Great Britain, as the leading shipbuilding nation, held a position not seriously challenged. We gave examples to the rest of the world; others took their practice from us. Of late, however, our supremacy has been attacked. There are shipyards and marine engine works, many of them splendidly equipped, in all the most important countries, and we may depend every effort will be made to employ them fully and develop them further. The naval Powers are determined to construct their navies within their own domains, and some foreign Governments are giving inducements to shipowners and shipbuilders of a substantial nature, and such as are not offered in this country. It is well to remember that Germany for some time past has not only possessed, but has constructed within her own domains, the mercantile vessels which hold the premier position in the world.

In shipbuilding, as in nearly all other manufacturing industries, we must neglect no chances. To design a complex structure such as a high-class modern steamship needs an amount of accurate knowledge intelligently applied—that is to say, an amount of science—which is only within the command of those having every advantage for its acquirement. We here say "design," not copy, for the man or the nation that copies must necessarily lag behind those who originate. It is not a good sign—it is distinctly a bad sign—that, in spite of the efforts of some public-spirited and thoughtful members of the Institution of Naval Architects, shipowners and shipbuilders at large have not subscribed the really modest sum needed for establishing the proposed experimental tank at the National Physical Laboratory. It is by the aid of such a tank that the data needed for the scientific design of a vessel can be worked out in their completeness; and such accurate knowledge as we have about resistance of ships is due to researches made by the aid of models in tanks. It is many years since an Englishman, Froude, established the first tank at Torquay, and, by his incomparable experimental work and scientific deductions, put at our disposal the information needed to prosecute further inquiries in this direction; and now, after more than thirty years, although we claim to be the leading shipbuilding nation of the world—as we are in regard to bulk of tonnage constructed—Mr. Yarrow has to depend on a German tank when he seeks information as to the resistance of vessels in varying depths of water. If our shipowners would devote a small part of the energy they expend, and an infinitely small part of the money they waste on freight-wars to an attempt to improve the designs of their vessels, it might tend to the stability of the British shipbuilding industry and to more satisfactory balance-sheets; it certainly would to a more worthy record of the country's progress in ship design.

Sir Philip Watts, who, as Director of Naval Construction, has at his command the well equipped and admirably staffed Government tank at Haslar, does not feel the need of such an establishment, and naturally does not refer to it in his paper. He gives, however, a sketch of the plan followed in scarphing frames and planking together so as to reduce the working of the different pieces on each other. The science of the metallurgist has removed that necessity by giving us a material which enables the side of a ship to be made practically a continuous structure. The outer planking of ships of the line at the time of Trafalgar was 8 inches to 4½ inches thick above water, and planking on the inside of the frames was from 4 inches to 5 inches thick. The frames themselves composed almost a solid wall, so that a combined thickness of nearly 2 feet—the thickness of the iron armour on the *Inflexible*—was available for resisting shot. Great attention was paid to seasoning timber; but when it came to a case of metal construction our ancestors were often a little at fault. "The older ships of the Trafalgar period were iron fastened and sheathed with copper. Considerable trouble was, however, experienced by the corrosion of the iron fastenings, so much so that in some cases, after three or four years, the ship was rendered unfit for foreign service. The intervention of substances such as felt, tarred paper, &c., between the copper and the wood bottom failed to protect the iron entirely, and at one time the Board of Admiralty contemplated discontinuing the sheathing of ships lying in ordinary and fitting it to them immediately before going to sea." Thus do we see how the want of a little knowledge of natural laws caused inefficiency and loss of money; but there was excuse for our predecessors which we, who have their accumulated experience, cannot plead.

Sir Philip Watts gives some interesting figures as to the cost of the older ships, and these may be compared with that of modern vessels. In 1719 the cost of the *Royal William*, of 1918 tons, was 30,800*l*., or about 16*l*. per ton. Whether or not this refers to Pett's *Royal William*, reconstructed in 1719, is not certain, but probably it does. In that case a good deal of the original structure might have remained, thus lessening the cost. The *Royal George*, of 2046 tons, built in 1756, cost 54,700*l*., or 26·7*l*. per ton. "In 1800 ships of the line cost 21*l*. per ton, whilst in 1805 the cost had risen to 35·4*l*. per ton." These figures presumably refer to displacement tonnage, but whether guns are included we are not aware; we will conclude they are not, and see how former figures compare with those of the present day. The first class battleship *King Edward VII.*, of 16,350 tons displacement, is to cost 1,410,901*l*., excluding guns and ordnance stores; whilst the guns will come to 89,070*l*., bringing the total cost to within a few pounds of a million and a half. This would be somewhat over 86·2*l*. per ton, without guns, as compared to 35·4*l*. per ton at the date of Trafalgar. If, however, we could measure cost in terms of fighting efficiency we should doubtless find that we now get more for our money than our fathers did in 1805, for the *King Edward VII.* could have engaged the whole of the British Fleet at Trafalgar with the allied fleet thrown in. In armament the advance has been no less striking. The old cast-iron smooth bores, with their wooden truck carriages, were trained by handspikes, used as levers under the brackets, and by side tackles; and they were elevated by handspikes, being held in position by quoins. Sir Philip Watts says that "a 32- or 24-pounder, fought on the lower deck, had a range of only about 2000 to 2500 yards with 8° elevation, and of about 1500 yards with 4° elevation. The powder charge was generally one-third to one-quarter the weight of the shot. At close quarters a 24-pounder was said to be able to penetrate nearly 5 feet of solid oak and an 18-pounder half this amount." These were not the heaviest guns in the service at the beginning of the last century, there being 42-pounders also; but guns of this nature, designed to form the principal armament for the lower decks of the largest battleships, were found to be too heavy to be worked quickly by the rude appliances then in use. A still heavier piece was later introduced, namely, the 95cwt. 68-pounder.

We have not information as to the thickness of solid oak which the round shot fired from these heavier natures would penetrate, but we may compare the 5 feet that would be pierced by the 24-pounder with the power of the guns of the present day. The modern 12-inch wire-gun of the Royal Navy, weighing 50 tons (about twenty times as much as the 32-pounder), is estimated to penetrate 42 inches of wrought-iron at muzzle velocity of 2580 foot-seconds and a muzzle energy of 39,280 foot-tons; at 1000 yards the penetration would be 38 inches of wrought-iron, at 2000 yards 34·6 inches, and at 3000 yards 32 inches. The penetration of Krupp steel armour at 3000 yards would be but 14 inches. These results are with uncapped projectiles. The longer 12-inch guns of Armstrongs or of Vickers will penetrate more than 51 inches of wrought-iron and will fire two rounds per minute.

It will be seen from the above facts how enormously the powers of both attack and defence have increased during the century. They would seem to have progressed in about equal ratio, for Sir Philip Watts says that "the capability of the wooden ship to take punishment from the guns of her time was, except in one important respect, much the same as that of a modern ironclad." The important respect, of course, refers to the shooting away of spars and rigging.

A table given by Sir Philip Watts comparing the weights apportioned to the different elements of design in a battleship of 1805 and of a modern battleship respectively is interesting. The old ship is one of 74 guns, and 20 per cent. of the total displacement was awarded to general equipment as against 4 per cent. for the 1905 battleship. Armament in 1805 was 10 per cent. of the displacement; in the present day it is 19 per cent. The propelling arrangements are somewhat in the nature of a surprise, masts, sails, and rigging absorbing 8·5 per cent., and steam machinery only 10·5 per cent. of the displacement. There is, however, to be added to the latter figure 5·5 per cent. for coal, but this is more than balanced by the 6·5 per cent. of the weight apportioned to ballast for giving the stability needed under sail. Armour is naturally the great point of difference, for it takes up 26 per cent. of the displacement of a modern battleship. As against this but 35 per cent. of the total displacement is needed for the construction of steel hulls, whilst the wooden hull absorbed 55 per cent. of the total tonnage. It must be remembered, however, that the construction of the "wooden walls" was far more massive than was needed for ordinary purposes, and a good part of the 55 per cent. might be set down as wooden armour. The remarkable thing is that iron plates were not applied earlier, before the French constructors set us the example; or, rather, it would be remarkable were the very conservative nature of the old admirals not remembered.

THE LIGHT-PERCEIVING ORGANS OF PLANTS.[1]

THE subject of this most suggestive book has already been dealt with by the author in a preliminary way.[2] In its present form it has gained greatly in force and interest, and whether or no we are finally converted to Prof. Haberlandt's views there can be no doubt that they are worthy of serious attention.

It is well known that the majority of leaves have the power of placing themselves at right angles to the direction of incident light, but the question of how the light stimulates the leaf to perform the curvatures and torsions which bring it into the "light position" is a problem which hitherto has hardly been attacked.

The first question to be solved is what part of the leaf is sensitive to light. By covering the blade of the leaf with black paper, &c., Haberlandt shows that the principal and most delicate sensitiveness resides in the blade, although a coarser and secondary sensitiveness to the incident light is found in the stalk. It results from this part of the inquiry that the lamina of the leaf must contain the organs for light-perception, if such organs exist. Anything corresponding to a visual organ may be expected to be on the surface, although in such a translucent organ as a leaf this does not necessarily follow. It may, however, be said that Haberlandt is amply justified in looking for what he calls the ocelli of plants in the epidermis covering the upper surface of the leaf. We may therefore narrow the problem thus. Imagine a horizontal leaf illuminated by light striking it obliquely from above at 45°; such a leaf is not in the "light position," and will execute a curvature through 45°, in fact until it receives light at right angles to its surface. Then curvature ceases and the leaf remains in a state of equilibrium—satisfied, as it were, with the "light position." The question is how the leaf differentiates between oblique and perpendicular illumination. Direct observation suggests an answer. If the epidermis of such a leaf as that of *Begonia discolor* be removed by a surface section, and mounted upside down and illuminated from below, then with a low power of the microscope it can plainly be seen that there is a bright spot of light on the basal (inner) walls of the epidermic cells. It can further be seen that the relation of the spot of light to the surrounding zone (which is more or less dark) changes when the specimen is obliquely illuminated. Thus in the case of the obliquely illuminated leaf we should have to imagine that the leaf is stimulated to curvature by the fact that the spots of light are not central in the cells, and that curvature ceases when the brightest illumination is once more central. Thus the plasmic membrane of the basal wall of each epidermic cell is supposed to have a quasi-retinal function by which the leaf is believed to orientate itself in regard to light. There is here, as Haberlandt points out, a certain resemblance to the mechanism by which plants are by many botanists believed to react to gravitation, namely, by the pressure of solid bodies on different parts of the cell walls, just as the statoliths (otoliths) of certain animals, by pressure on different parts of the membrane of the statocyst, enable them to orientate themselves in space.

Haberlandt shows that the epidermic cell is well fitted to concentrate light. It is very commonly lens-like in form, its outer wall being convex, its inner wall either plane or curved. Haberlandt shows by geometrical construction that, taking the refractive index of the cell sap as equal to that of water, the focus is usually at a point either within the cell or below it in the other tissues. In either case a central illuminated region and a surrounding dark zone is produced on the basal cell wall. A further development of this type is the papillose epidermic cells which give the velvety appearance to certain tropical leaves. This does not differ essentially from the first described type, but it has, according to the author, certain advantages which will be referred to later on. It must not be supposed that all leaves have lens-shaped epidermic cells; some leaves, known as aphotometric, are indifferent to the direction of incident light, and even in photometric leaves Haberlandt shows that discrimination is possible without the epidermis playing the part of a lens. Where the outer wall of the epidermis is flat, it often occurs that the inner wall bulges into the subjacent tissues or projects into them in the form of a truncated pyramid. In this case, when the light strikes the leaf at right angles, the central part of the basal wall, being more or less parallel to the surface, is more strongly illuminated than its peripheral parts, which are oblique. Thus without any lens-effect we get stronger illumination in the central region of the basal walls of the epidermis; and this may conceivably serve as a means of orientation.

The most conclusive proof of the author's theory is given by the results of placing the experimental plants under water. If he is right in claiming a lens-function for the epidermic cells, it is clear that immersion in a fluid which has approximately the same refractive index as the cell sap must interfere with the plant's power of light-perception; and this is, in fact, the outcome of his experiments.

His first experiments (p. 89) were made with the hop (Humulus). Here, as in other cases, the stimulus of light is perceived by the leaf, and less perfectly by

---

[1] "Die Lichtsinnesorgane der Laubblätter." By Dr. G. Haberlandt o. ö. Professor der Botanik a. d. Universität Graz. Pp. viii+143 (Leipzig: Engelmann, 1905.) Price 6*s*. net.

[2] *Berichte d. deutsch bot. Gesellschaft*, Bd. xxii., 1904 (February), and in an address given in 1904 before the Gesellschaft deutscher Naturforscher und Aezte, and published by Barth, of Leipzig.